MEASUREMENT OF SPEED OF SOUND

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Objectives

- To develop a freshmen year lab experiment.
- Student will learn to verify speed of sound experimentally with two different methods.
- Sound speed variation through different gases(tentative).

Methods

- Time of flight (TOF)
- Resonance method

Time of flight

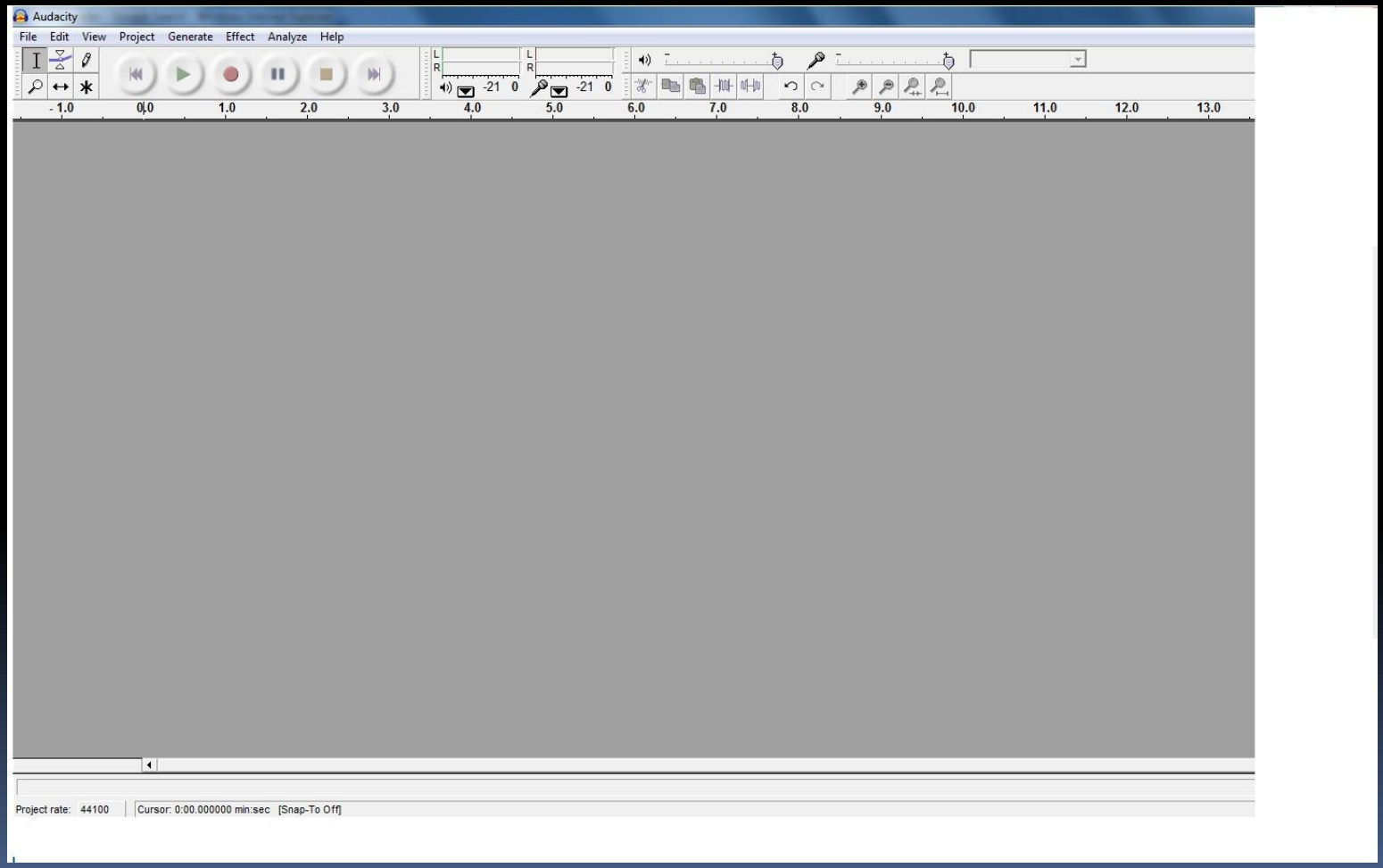
- A source of sound is placed in front of two microphones, which are at ‘d’ distance from each other(ideally at the same height).
- Sound wave reaches the nearer mic first and then to the second.
- Time difference of sound reaching both is Delta (t).
- From v=d/delta(t),we can calculate speed of sound.

But how to find time difference?

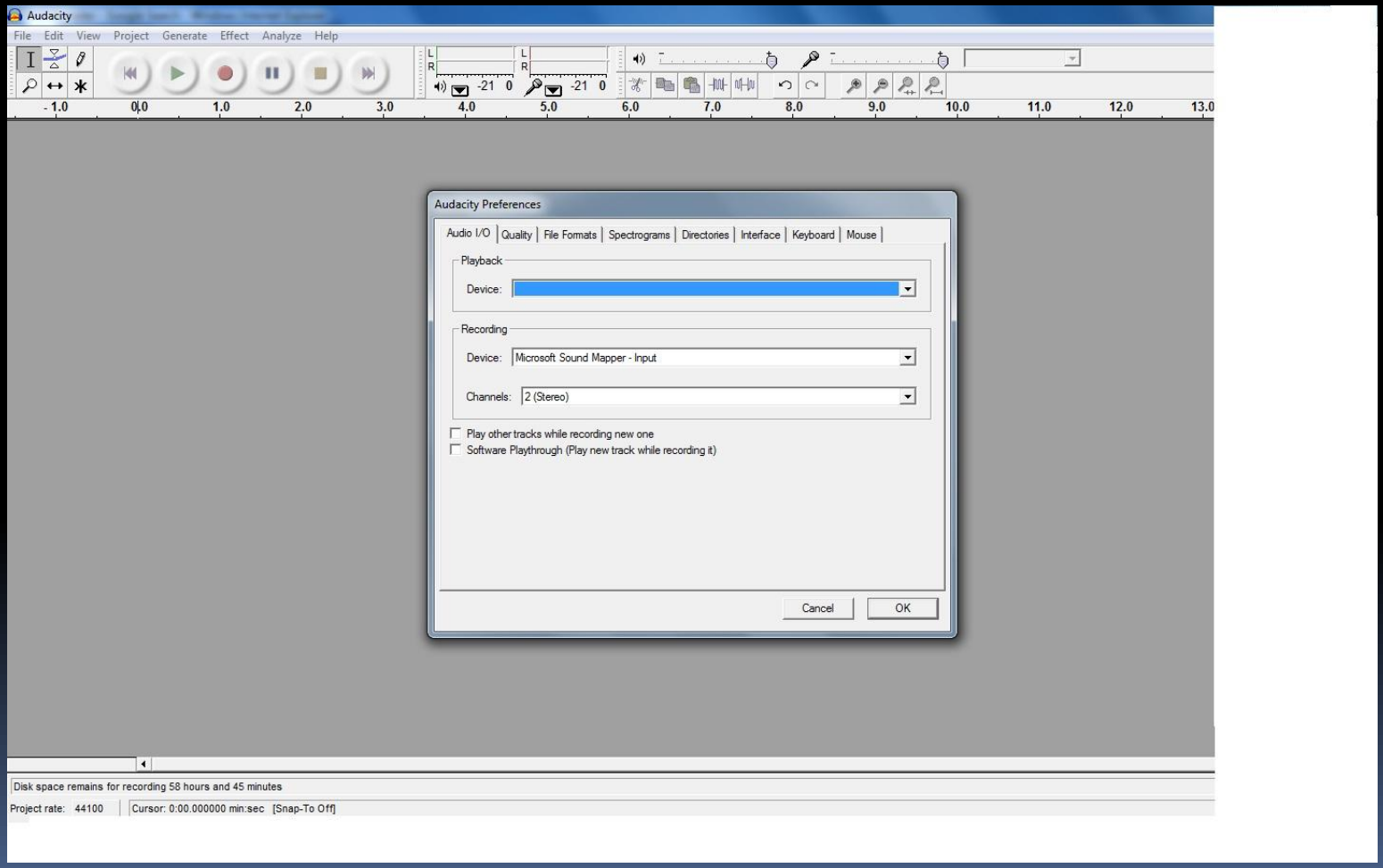
- We exploit the stereo nature of sound card in our computer and connect these microphones to sound card through jack.
- A freeware software,audacity,helps us to find delta(t).

Reminder : Speed of sound in air (at 293.15 K / 20 C) is 343.2m/s.

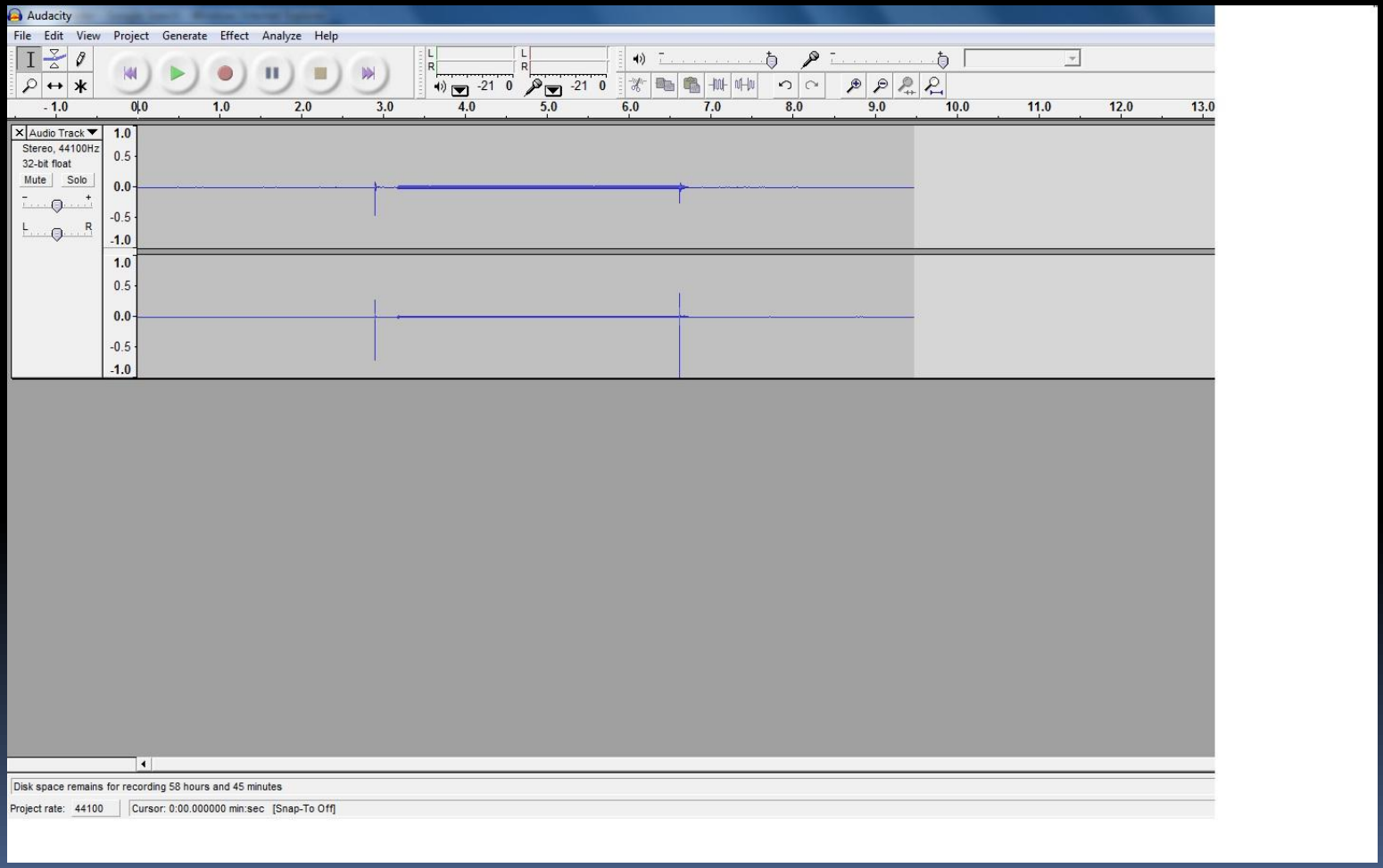
Audacity interface



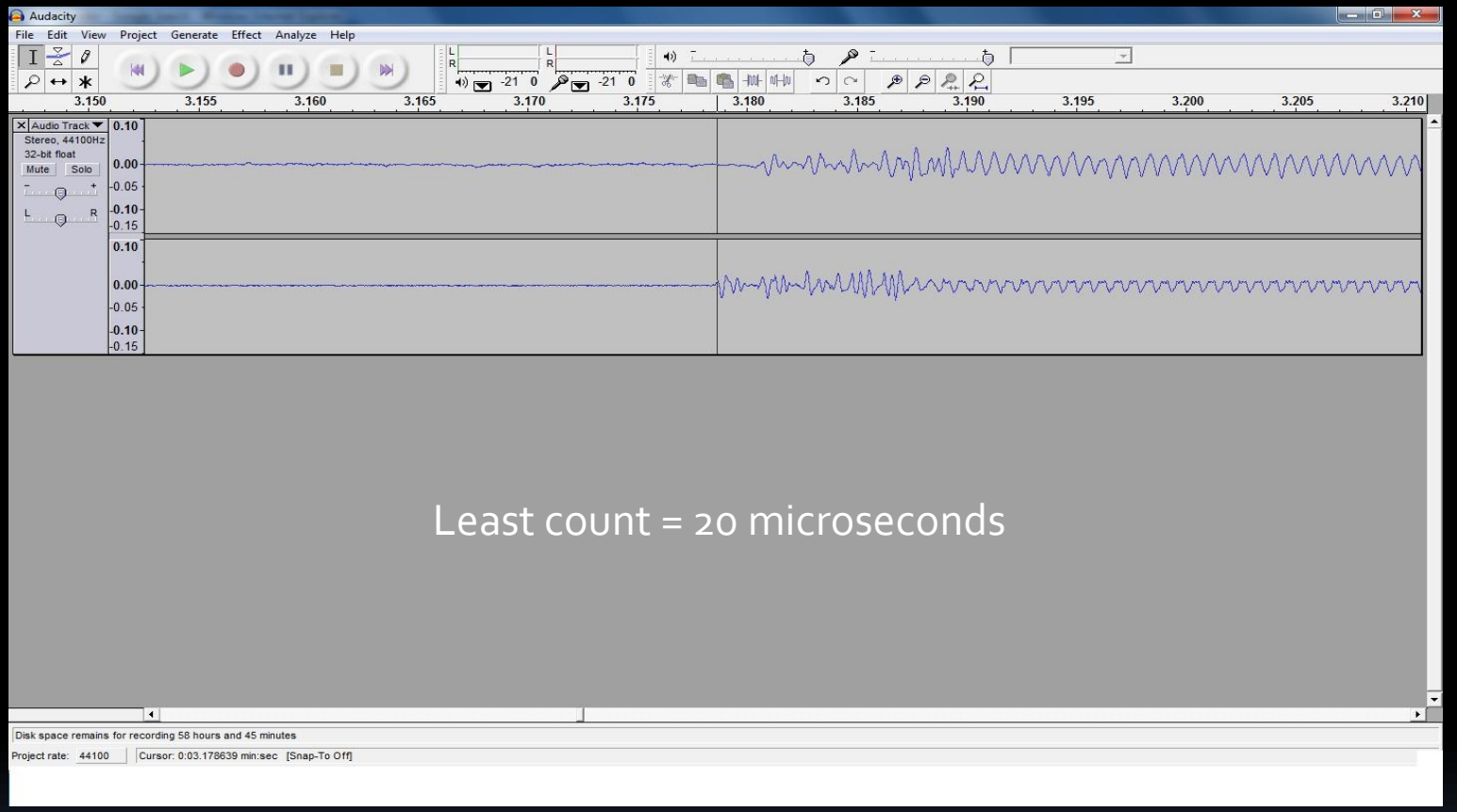
Stereo option



Driving speaker with function generator

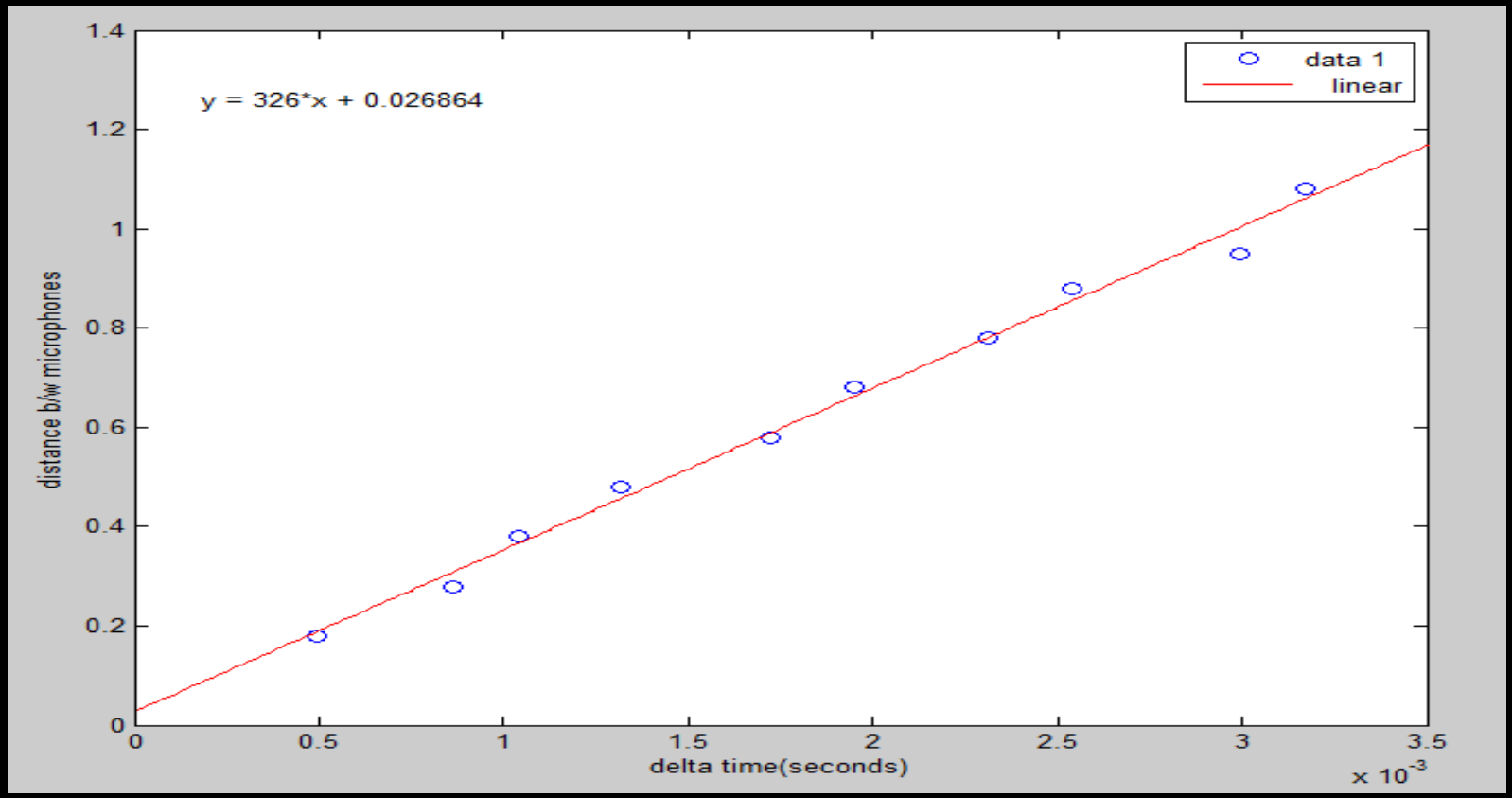


Resolution in time and amplitude by zoom in



Least count = 20 microseconds

Now we know delta(t) and ‘distance’,so we can easily find speed of sound.


y = 326*x + 0.026864
data 1
linear
distance b/w microphones
delta time(seconds)
x 10^-3
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
0.5
1
1.5
2
2.5
3
3.5

Resonance method

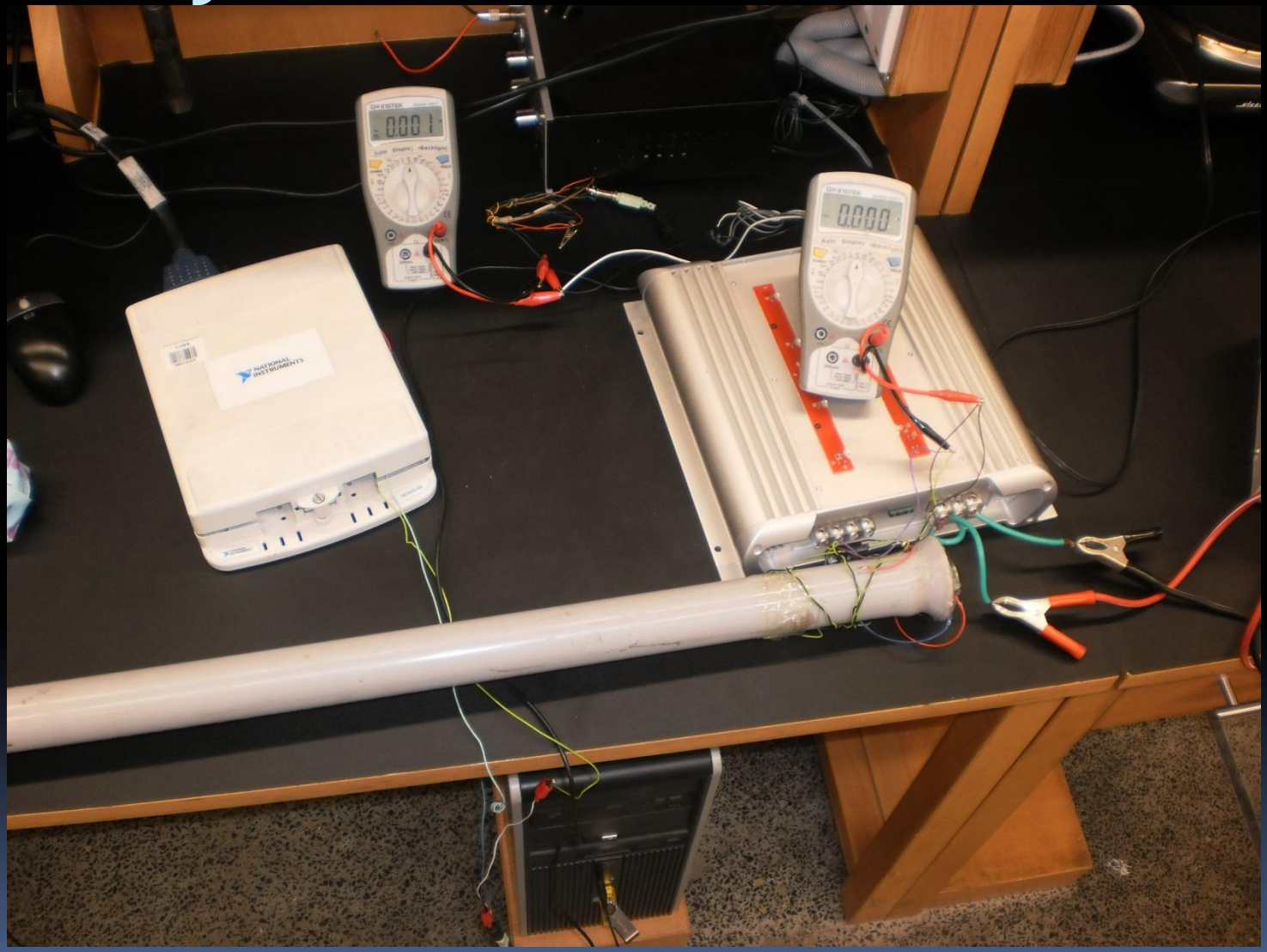
- It exploits the idea of generation of standing wave in a closed pipe.
- Speaker at one end of pipe which is driven by an audio amplifier.
- Microphone at the other with output going in sound card for further processing.
- Resonance must occur at $f=(n*v)/(2*L)$
- Where, f is frequency of wave

  n is number of harmonic

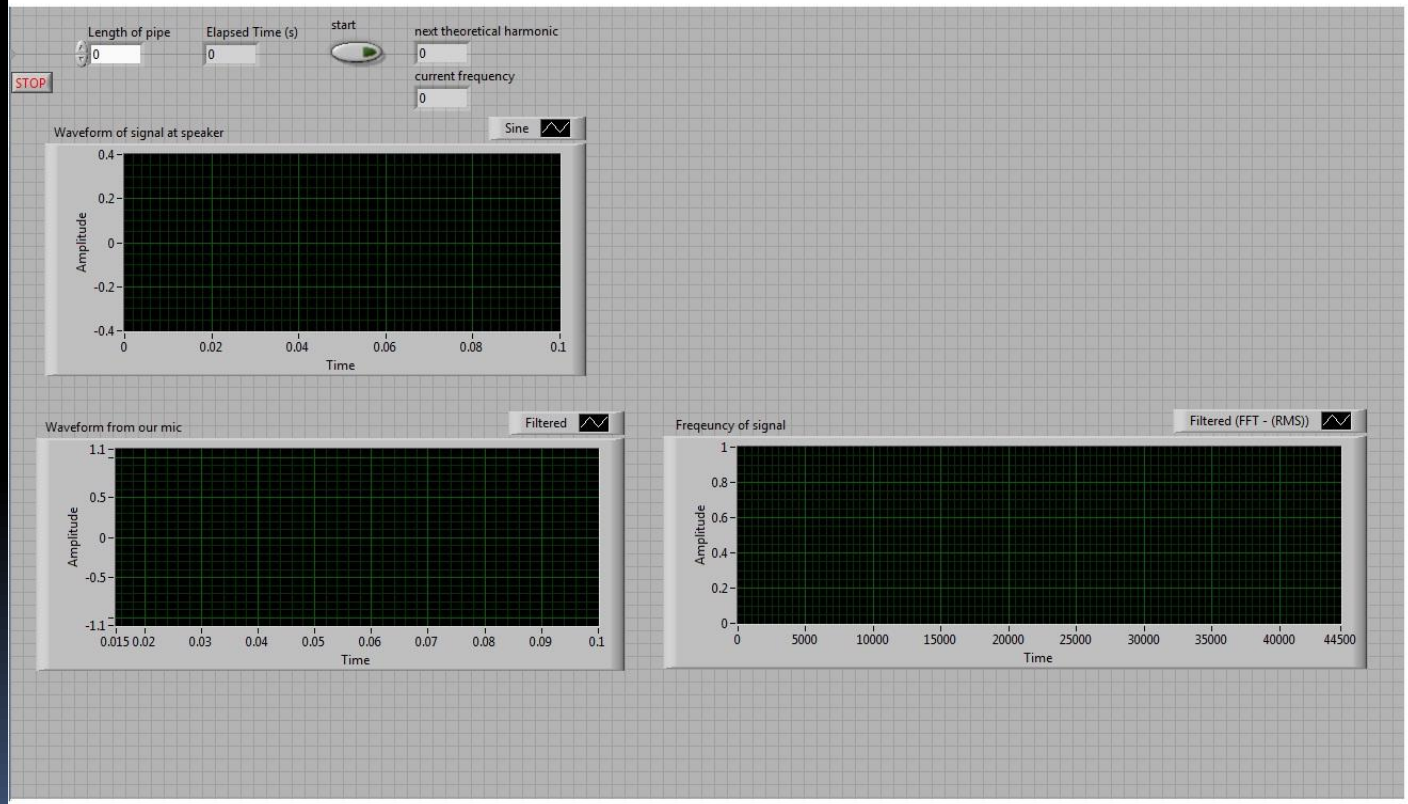
  v is velocity of sound

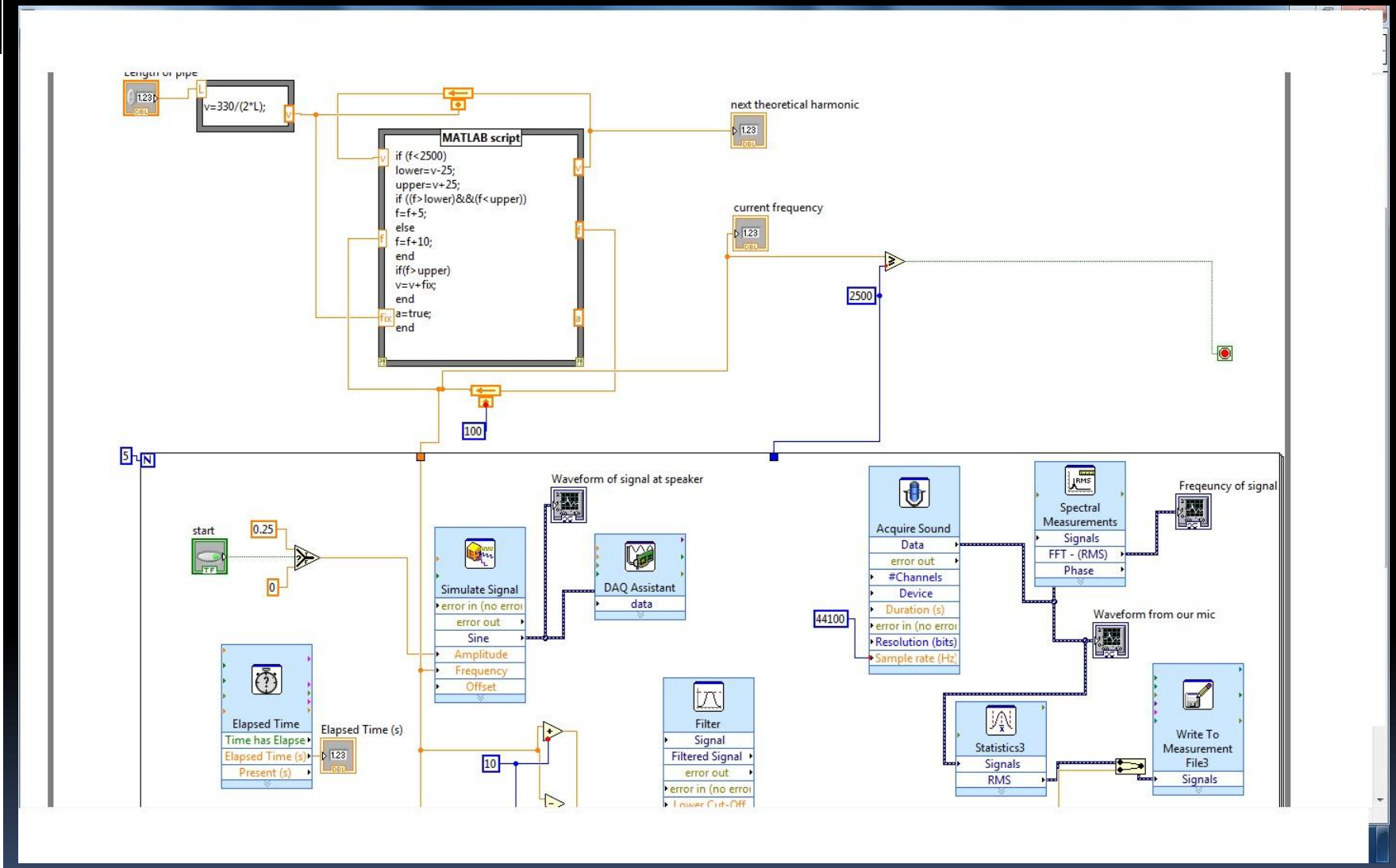
  L is length of closed pipe

Our system

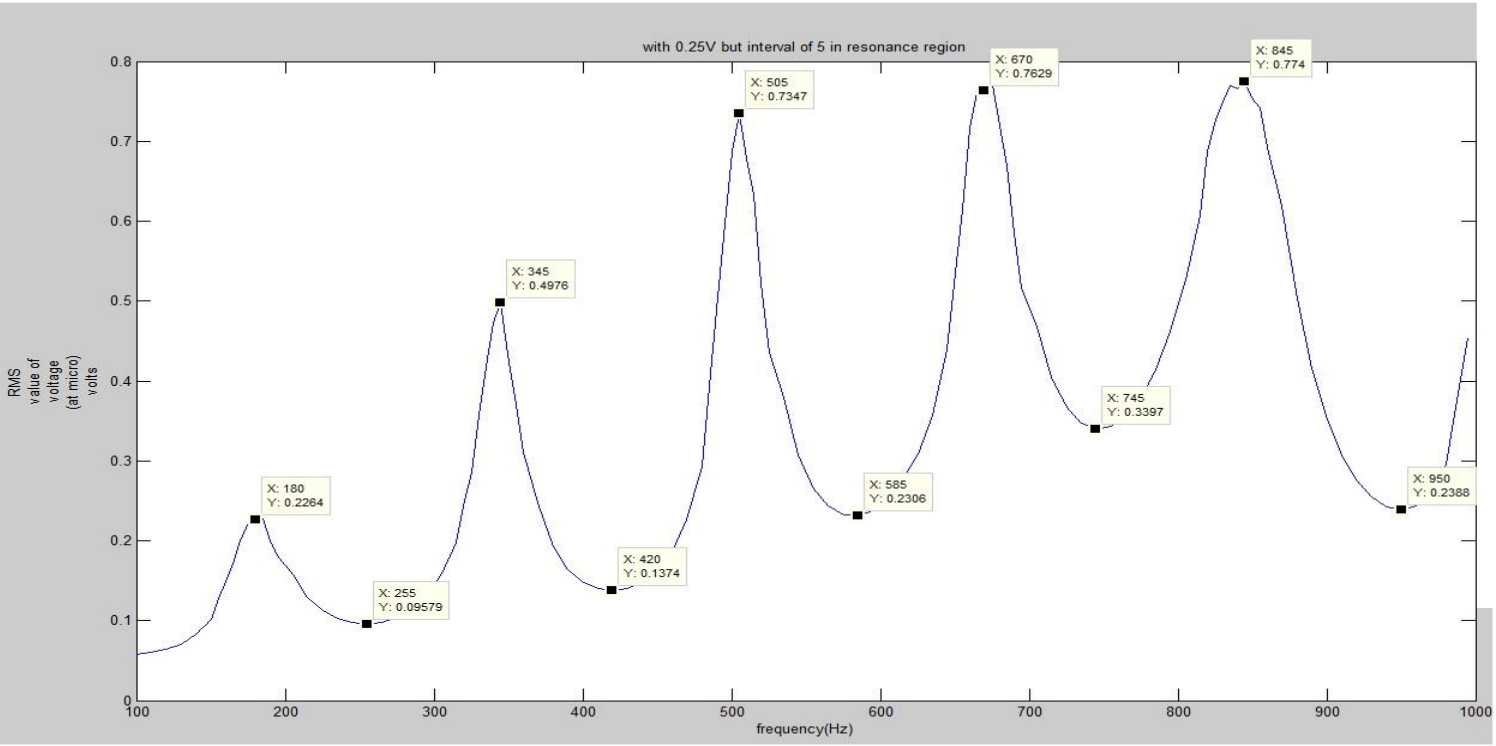


Labview files




v=330/(2*L);
MATLAB script
if (f<2500)
lower=v-25;
upper=v+25;
if ((f>lower)&&(f<upper))
f=f+5;
else
f=f+10;
end
if(f>upper)
v=v+fix;
end
a=true;
end
next theoretical harmonic
current frequency
2500
100
5
N
start
0.25
0
Simulate Signal
error in (no error)
error out
Sine
Amplitude
Frequency
Offset
Waveform of signal at speaker
DAQ Assistant
data
Elapsed Time
Time has Elapse
Elapsed Time (s)
Present (s)
Elapsed Time (s)
10
Filter
Signal
Filtered Signal
error out
error in (no error)
Acquire Sound
Data
error out
#Channels
Device
Duration (s)
error in (no error)
Resolution (bits)
Sample rate (Hz)
44100
Spectral Measurements
Signals
FFT - (RMS)
Phase
Freqeuncy of signal
Waveform from our mic
Statistics3
Signals
RMS
Write To Measurement File3
Signals

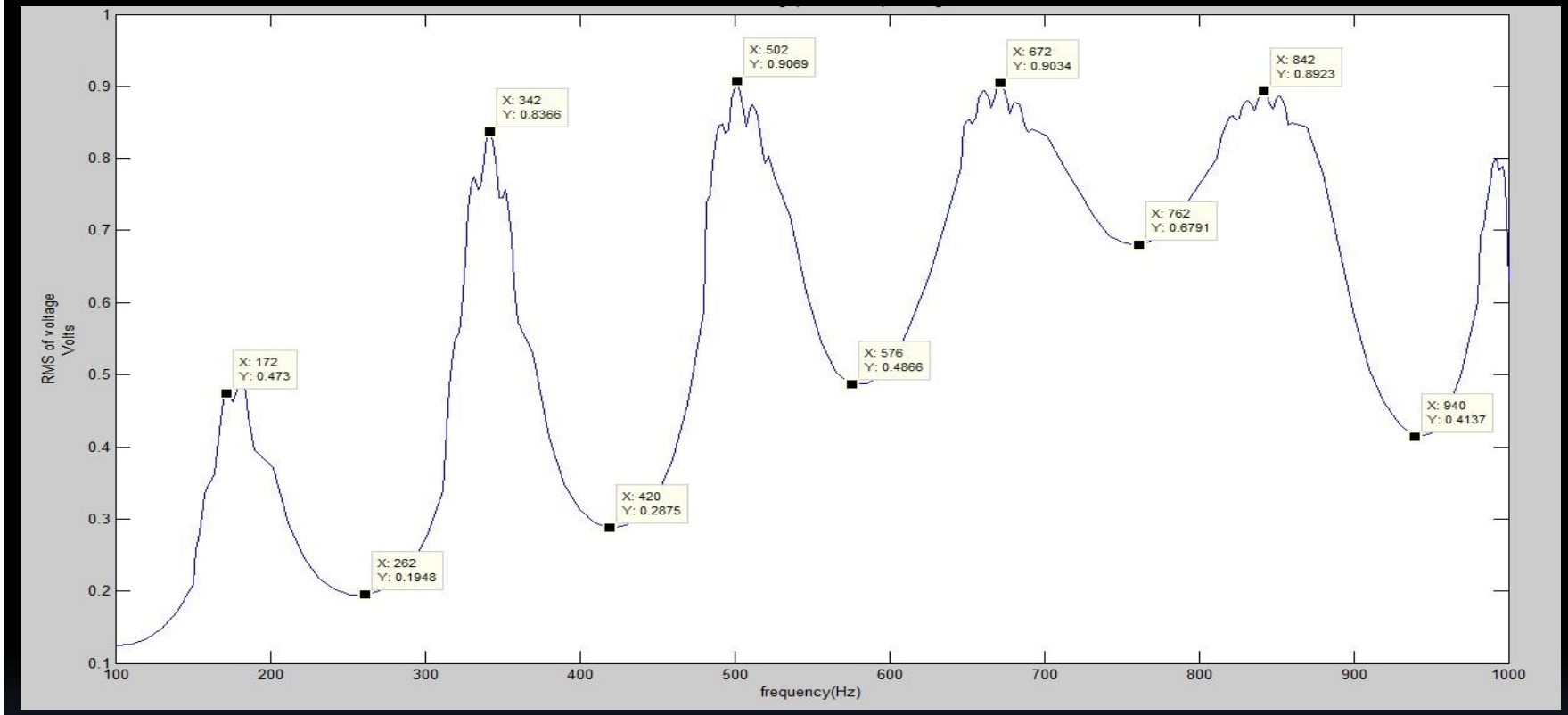
Results with length=0.99m



Average speed of sound comes out to be 339.50 m/s (by calculating speed at every harmonic and taking average)

Resolution in resonance region is 5 Hz frequency

With sensitivity of 2 Hz frequency



Average speed of sound comes out to be 335.30 m/s (by calculating speed at every harmonic and taking average)

Speed in different Gases

- Speed is directly proportional to square root of temperature.
- Inversely proportional to square root of mean molecular weight of the gas.

All credit goes to **Yousaf** and Hafiz Rizwan!

- Third method is to throw white noise in the pipe .

Questions!?

- Thanks for the attention.